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## ABSTRACT

This course guide for an electrical/electronic technology course is one of four developed for the energy/power area in the North Dakota senior high industrial arts education program. (Eight other guides are available for two other areas of Industrial Arts--graphic communications and production.) Part 1 provides such introductory information as a definition and instructional objectives for Industrial Arts. Part 2 contains the course rationale and objectives; guidelines for implementation; taxonomic structure; course description including length, credit, prerequisites, and student competencies; suggested instructional units with required number of class periods; and 19 units. Each unit includes some or all of the following material: unit objective(s), topic outline, and selected student competencies to be developed through sample coordinated learning activities. Unit titles are Introduction to Electrical/Electronic Technology; Electronics Industry Definitions; Measurements and Instruments; Symbols, Components, Ratings; Circuit Arrangements; Electrical Relationships; Alternating Current Fundamentals; Capacitive Circuits; Magnetism and Magnetic Circuits; Frequency Selective Circuits; Motors and Generators; Residential Electrical Wiring; Careers in Electrical Industry; Introduction to Electrical Applications and Careers; Discrete Semiconductor Devices and Circuits; Introduction to Digital Electronics; Basic Arithmetic Devices; Basic Support Devices; Microprocessor Basics and Applications; and Electronic Assembly Methods. A reference list is appended. (YLB)

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# ELECTRICAL / ELECTRONIC TECHNOLOGY

(ENERGY / POWER)

## INDUSTRIAL ARTS SENIOR HIGH--LEVEL II

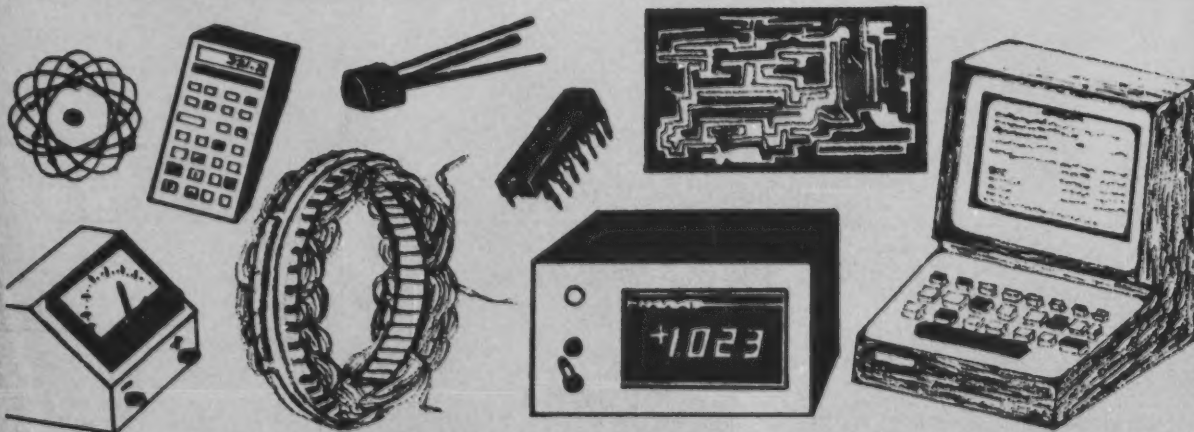
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NORTH DAKOTA STATE BOARD FOR  
VOCATIONAL EDUCATION  
Bismarck, North Dakota

CE030555

# **NORTH DAKOTA SENIOR HIGH INDUSTRIAL ARTS CURRICULUM GUIDES**

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## PREFACE

One of the biggest challenges facing education today is keeping the instructional content current. Industrial Arts in particular must be quick to respond to changes in our technological society. For many years, North Dakota has offered quality industrial arts programs to students in the public schools. Credit for this is due to the teachers who have shown the desire to continually improve programs, keep their content current, and make instruction relevant.

The Industrial Arts curriculum has boundless potential for courses and program development. However, this program possibility excites the imagination of teachers to offer endless number of courses which causes a need to determine what is of greatest value for students to experience.

Thus, the development of an appropriate or model curriculum requires a critical examination of several undergirding questions: What is the overall responsibility of Industrial Arts? What Industrial Arts goals are appropriate for the different grades or school levels? What courses constitute a meaningful curriculum for these goals to be realized? What shall be the scope and sequence of the total curriculum? The answers to these questions have been addressed by a North Dakota Industrial Arts Master Plan curriculum committee and are recorded in the North Dakota Senior High Industrial Arts Program of Studies booklet.

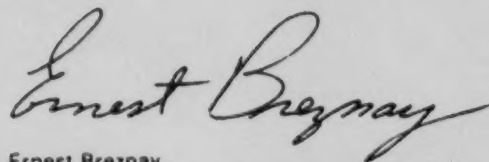
The Program of Studies describes the complete secondary school industrial arts education. The Program of Studies Booklet emphasizes the Level II Senior High programs with specific courses, course descriptions, objectives and units of instruction. The Junior High-Level I program is dealt with in a general basis for the purpose of articulating the two levels within the total secondary school industrial arts program.

Three types of Industrial Arts programs are included in the Program of Studies along with the individual courses which constitute the complete secondary school curriculum:

1. **ORIENTATION AND EXPLORATION**-- Level I program designed for grades seven through nine.  
The purpose of this program is to provide students with first-hand exploratory experiences in the four technical cluster areas. The learning experiences should provide an awareness of the impact of industry and it's associated technologies on the lives of individuals. Furthermore, this program assists individuals in making informed and meaningful occupational/career choices.
2. **PERSONAL ENRICHMENT**-- The program designed to prepare students with a general education of technological literacy, avocational skills and consumer information. This is purely an elective program of students for students who desire to gain an understanding of the technical concepts for personal satisfaction.
3. **PRE-TECHNICAL**-- This program provides concentrated and specialized technical courses for grades ten through twelve. These courses are articulated with the Level I technical cluster areas. Students at this level have a wide range of interests, abilities, and life aspirations. Therefore, the key element for the senior high pre-technical program is flexibility to meet the varied needs of learners. The program is designed to prepare students for advanced educational or training programs.

The North Dakota Senior High Program of Studies identified twelve different courses recommended to be offered in grades ten, eleven and twelve. The model curriculum lists four courses for each of three technical areas: (1) Energy/power, (2) Graphic Communications, and (3) Production. Individual course guides have been developed for each of the twelve courses recommended for the senior high curriculum. This being one of the twelve course guides. Similar guides have been developed for the remaining eleven.

Each course guide contains the course rationale, objectives, content, units and selected student competencies to be developed along with student learning activities. The primary aim of the course guides is to provide meaningful direction and still leave opportunity for individual teacher creative approaches in meeting the diverse needs of unique school populations. The course guides not only propose to assist teachers and administrators in keeping their programs up-to-date, but also to promote industrial arts education program uniformity among North Dakota schools.



Ernest Breznay  
State Industrial Arts Supervisor  
North Dakota State Board for Vocational Education  
July, 1981

## ACKNOWLEDGEMENTS

The North Dakota Industrial Arts profession is indebted to the following individuals who gave their time and talents in the development of the Twelve Senior High Industrial Arts course guides. These teachers and teacher educators attended an Organizational meeting, participated in a curriculum writing seminar, and developed individual course guides during 1980 & 1981.

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## BASIC BELIEFS ABOUT INDUSTRIAL ARTS

### INDUSTRIAL ARTS IS .....

- \*an educational discipline founded upon the knowledge base of technology - the means by which material things are produced.
- \*an instructional program affording boundless opportunities for learning how technology has been, is now and will be basic to human desires and needs.
- \*a fundamental educational program that can serve educational priorities, whether they are academic education, general education, vocational education, career education, ad. inf.
- \*an activity based curriculum enabling students to learn through doing.
- \*logically a discipline with a curriculum continuum from grade K through 12.

### INDUSTRIAL ARTS IS JUSTIFIED BECAUSE .....

- \*all persons need to know about the technological environment, the material culture, and industry because they are economically, socially and emotionally affected by them.
- \*all persons must make a career choice from an extremely large and increasing number of occupations that are affected by technology; therefore, they should have opportunities to develop interests, uncover talents, explore technical and applied science fields and study occupations.
- \*all persons must select, buy, use, and maintain the products of industry -- houses, automobiles, appliances, clothes, furniture and items of a never ending list. A knowledge of products, their manufacture, characteristics, advantages and disadvantages makes for intelligent consumption.
- \*all persons need recreational, leisure time and avocational outlets.
- \*all persons need to have opportunities to develop planning, creative, problem solving and technical skills in harmony with their inherent desire to seek the better way.

### INDUSTRIAL ARTS CAN HELP THE STUDENT TO .....

- \*gain an understanding of industry and technology.
- \*discover interests and talents.
- \*develop techniques in problem solving.
- \*develop basic skills in the safe use of tools and machines.
- \*make informed and meaningful occupational choices.
- \*acquire interests in avocational pursuits and hobbies.
- \*develop safe working habits.
- \*apply other school subjects.
- \*become a wiser consumer.
- \*develop creativity.
- \*develop pride in work well done.
- \*work cooperatively with others.

## **THE INDUSTRIAL ARTS MISSION**

The mission of Industrial Arts Education is to assist the student in developing an understanding about industry and technology and in the discovery and development of individual potential.

### **GOALS**

Consistent with their abilities, interests and educational needs:

1. Industrial Arts students at the middle or junior high school level will be aware of employment and/or self-employment opportunities and requirements for use in making career choices and in determining their educational programs.
2. Industrial Arts students at the senior high school level will acquire technical competencies in preparation for advanced vocational or technical education programs.
3. Industrial Arts students at the senior high school level will acquire competencies that lead to responsible citizenship through technological understanding, consumer knowledge and the productive use of leisure time.

### **INDUSTRIAL ARTS: AN OFFICIAL DEFINITION**

Industrial Arts education programs means those education programs which pertain to the body of related subject matter, or related courses, organized for the development of understanding about the technical, consumer, occupational, recreational, organizational, managerial, social, historical, and cultural aspects of industry and technology including learning experiences involving activities such as experimenting, designing, constructing, evaluating, and using tools, machines, materials, and processes which provide opportunities for creativity and problem solving or assist individuals in the making of informed and meaningful occupational choices or which prepare them for entry into advanced trade and industrial or technical education programs.

## **INDUSTRIAL ARTS INSTRUCTIONAL OBJECTIVES**

Industrial Arts students at the Senior High School Level will acquire competencies that lead to responsible citizenship through technological understanding, consumer knowledge and the productive use of leisure time. The program stresses the following instructional objectives:

1. Develop an insight and understanding of industry and technology, its place in our society and the free enterprise system.
2. Discover and develop individual talents, aptitudes, interests, and potentials as related to industry and technology.
3. Develop an understanding of industrial processes and the practical application of scientific principles.
4. Develop technical problem-solving and creative abilities involving the use of materials, processes, and products of industry and technology.
5. Develop an understanding of industrial and technological career opportunities and their requirements and develop those traits which will help students obtain and maintain employment.

As determined by Title II of PL No. 94-482, the Vocational Education Act of 1976 and the State Board for Vocational Education, the purpose of funding industrial arts programs with vocational monies will be to:

1. Assist individuals in the making of informed and meaningful occupational and educational choices.
2. Prepare individuals for enrollment in advanced or highly skilled vocational and technical programs.

# NORTH DAKOTA INDUSTRIAL ARTS CURRICULUM

Program Scope and Sequence Model

## JUNIOR HIGH LEVEL I

(7-9)

Orientation and Exploration

## ELEMENTARY LEVEL

(k-5)

Awareness

At the elementary level, learning experiences in industrial arts will be directed primarily toward the child's development of an awareness of industry/technology and the world of work. The concepts and activities will be integrated with the elementary curriculum to enrich and reinforce the common learning areas.

## INSIGHTS INTO INDUSTRY & TECHNOLOGY

A broad overview of industry and technology. Learning experiences will be directed toward the student's exploration of the historical, present, and future potentials of industry and technology.

## GRAPHIC COMMUNICATIONS TECHNOLOGY

## MANUFACTURING TECHNOLOGY

## CONSTRUCTION TECHNOLOGY

## ENERGY/POWER TECHNOLOGY

## SENIOR HIGH LEVEL II

(10-12)

Personal Enrichment

Pre-Technical

DESIGN/DRAFTING  
PHOTOGRAPHY  
GRAPHIC ARTS  
CONSTRUCTION  
DRAFTING  
INDIVIDUAL TECHNICAL  
PROBLEMS

## PRODUCTION

WOOD TECHNOLOGY  
PLASTIC TECHNOLOGY  
METAL TECHNOLOGY  
INDUSTRIAL CRAFTS  
INDIVIDUAL TECHNICAL  
PROBLEMS

ENERGY SOURCES  
POWER TECHNOLOGY  
ELECTRICAL / ELEC-  
TRONIC TECHNOLOGY  
TRANSPORTATION  
TECHNOLOGY  
INDIVIDUAL TECHNICAL  
PROBLEMS

## THE INDUSTRIAL ARTS PROGRAM OF STUDIES

| LEVEL                                                           | GOAL                                                         | PROGRAM                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>II</b><br><br><b>HIGH SCHOOL</b><br>(Grades 10, 11, & 12)    | <b>1. Personal Enrichment</b><br><br><b>2. Pre-Technical</b> | <b>GRAPHIC COMMUNICATIONS TECHNOLOGY</b><br>*Design/Drafting<br>*Photography<br>*Graphic Arts<br>*Construction Drafting<br>*Industrial Technical Problems                                                                                                                                                                                                                                                                                               |
|                                                                 |                                                              | <b>ENERGY/POWER TECHNOLOGY</b><br>*Energy Sources<br>*Power Technology<br>*Electrical/Electronic Technology<br>*Transportation Technology<br>*Individual Technical Problems<br><br><b>PRODUCTION TECHNOLOGY</b><br>*Wood Technology<br>*Metal Technology<br>*Plastic Technology<br>*Industrial Crafts<br>*Individual Technical Problems<br><br><hr style="border-top: 1px dashed black;"/> <b>INDIVIDUAL TECHNICAL PROBLEMS</b><br>(Multiple Offerings) |
| <b>I</b><br><br><b>JUNIOR HIGH SCHOOL</b><br>(Grades 7, 8, & 9) | <b>1. Orientation</b><br><br><b>2. Exploration</b>           | *Insights Into Industry and Technology<br>*Graphic Communications Technology<br>*Manufacturing Technology<br>*Construction Technology<br>*Energy/Power Technology                                                                                                                                                                                                                                                                                       |

# PROGRAM STANDARDS FOR INDUSTRIAL ARTS

## ELEMENTS OF QUALITY INDUSTRIAL ARTS PROGRAMS

The success and quality of programs in industrial arts education depends upon elements that influence the quality of programs. Industrial arts must be responsive to the following elements:

- A. **GOALS AND OBJECTIVES:** Program goals and objectives are established that provide the inspiration and guidance in program development, operation and evaluation.
- B. **INSTRUCTIONAL STAFF:** The instructional staff is competent and meet necessary qualifications.
- C. **INSTRUCTIONAL PLAN:** Selected subject matter is appropriate to learner's level and consistent with curriculum and course goals and objectives.
- D. **STUDENT ORGANIZATIONS:** The establishment and operation of effective student organizations.
- E. **FACILITIES AND EQUIPMENT:** Instructional facilities are well-designed, located and supportive of accomplishing curricular goals. (Refer to Educational Specifications for Industrial Arts Instructional Facilities Handbook, 1978.)
- F. **SPECIAL NEEDS:** The program must provide for disadvantaged and handicapped students.
- G. **ADVISORY COMMITTEES:** The establishment and effective use of industrial arts advisory committees.
- H. **GUIDANCE:** The teacher's role in guidance.
- I. **ADMINISTRATION:** Administration of the industrial arts program.
- J. **EVALUATION:** Evaluation procedures are planned and implemented to assure continual program improvement.

**NOTE:** For further information on program standards, refer to the NORTH DAKOTA VOCATIONAL/ TECHNICAL EDUCATION PROGRAM STANDARDS, Section 11.1 to 11.7.

## **INDUSTRIAL ARTS COURSE CODE NUMBERS (Vocationally Funded)**

|                                             |       |
|---------------------------------------------|-------|
| Insights Into Industry and Technology ..... | 10001 |
| Construction Technology .....               | 10011 |
| Manufacturing Technology .....              | 10021 |
| Wood Technology .....                       | 10023 |
| Metal Technology .....                      | 10026 |
| Plastic Technology .....                    | 10029 |
| Energy and Power Technology .....           | 10031 |
| Electrical/Electronic Technology .....      | 10033 |
| Energy Sources .....                        | 10038 |
| Power Technology .....                      | 10039 |
| Graphic Communications Technology .....     | 10051 |
| Graphic Arts .....                          | 10052 |
| Design/Drafting .....                       | 10053 |
| Photography .....                           | 10054 |
| Construction Drafting .....                 | 10056 |
| Transportation .....                        | 10061 |
| Industrial Crafts .....                     | 10080 |
| Individual Technical Problems .....         | 10091 |
| Individual Technical Problems .....         | 10092 |

**PART II:**  
**ELECTRICAL / ELECTRONIC**  
**TECHNOLOGY COURSE GUIDE**  
**(# 10033)**

## ELECTRICAL / ELECTRONIC TECHNOLOGY

### Rationale:

The purpose of studies in the energy/power area is to develop a realization, through activity-oriented instruction, that energy availability, conversion, efficient usage, conservation, and futuristic concerns are essential to life. Studies about energy/power involve both classroom and hands-on activities. These studies should prepare the student to consider not only the technological phenomenon, but also the socioeconomic and environmental impacts and the occupational aspects of the energy/power field.

The purpose of a course in electrical/electronic technology is to prepare the student to consider in further detail the essential elements of a very important and flexible form of energy (electricity) and to introduce a new concept based on electricity (electronics) that unites many concepts including energy control, communication, information storage/handling, and an individual's relationship with technology and the environment. Many of the problems resulting from technology demand electrical or electronic solutions. Therefore, a course in this area is both logical and beneficial.

### Course Objectives:

- (1) To provide students with the opportunity to reflect on the increasing dependence of society on electricity, energy/power, and on the ever widening impact of electronic devices on our daily lives.
- (2) To provide students with the necessary theory and experiences which will enable them to solve problems associated with electrical/electronic equipment.
- (3) To provide students with the experiences necessary to take advantage of occupational and avocational opportunities in the electrical/electronic fields.
- (4) To provide an atmosphere which will stimulate development of a safety conscientiousness with regard to electrical/electronic devices.
- (5) To provide an environment which will permit students to wisely accept, purchase, and utilize new electrical and electronic devices.

### Guidelines For Implementation

Success in the classroom or laboratory depends on many factors. Foremost among these is the planning effort on the part of the teacher. Educational programs must be flexible and adaptable. They must be flexible enough to remain adaptable to all locales, in numerous types of facilities, and with students possessing differing values and interest. Therefore, a successful program must be capable of application in both small and large schools.

The industrial arts program recommended by these course guides are designed to meet individual student needs. They provide teachers with guidelines for a well balanced program with suggested teacher options in each of the three major technical study areas: (1) Graphic Communications; (2) Energy/Power; and (3) Production. The North Dakota secondary school industrial arts program suggests three levels of learning with an alternative curriculum approach at the Level II for those schools that cannot offer specific courses identified for each of the three technical study areas due to the size of enrollments or other limiting factors.

## Energy / Power Technical Area Guidelines

The recommended scope and sequence of course offerings for the energy/power technical study area is illustrated on the sample program model on page 13. The Level I Energy/Power Technology course serves as an orientation and exploration experience. It is recommended as a prerequisite to the four Level II courses. The senior high Level II courses provide concentrated and indepth exploratory experiences in four study areas related to energy/power: (1) Energy Sources; (2) Power Technology; (3) Electrical/Electronic Technology; and (4) Transportation Technology. Since students at the senior high level display a wide range of interest, abilities, and life goals, the industrial arts program must provide a variety of learning experiences and course options to meet individual student needs, it is recommended that the specific course options be made available to students when possible. For the smaller mid-sized schools, it may not be feasible to offer all four of the specific courses identified for Level II. If that should be the case, it is recommended that one or two of the courses be offered and supplemented by an ITP (Individual Technical Problems) course as a Level II alternative. (See ITP Course specifications on page 14.) This course is designed to provide multiple learning experiences in the technical area of energy/power to meet individual needs of students.

The Level III ITP specialized course (Code #10092) is suggested for students in larger programs who have had the Level II indepth exploratory courses in energy/power and desire to study a specialized aspect related to any phase of energy/power technology. The student may select a technical problem in such areas as alternate energy sources, energy conversion, transmission, and others. (See pages 15 and 16 for the specific ITP specialized course specifications and technical problem options).

## **Guidelines For Implementing the Electrical / Electronic Technology Course**

The electricity/electronics fields are advancing at an unprecedented rate. This presents the teacher of a multiple activity program with an almost impossible task of keeping up to date and presenting constantly new and relevant material.

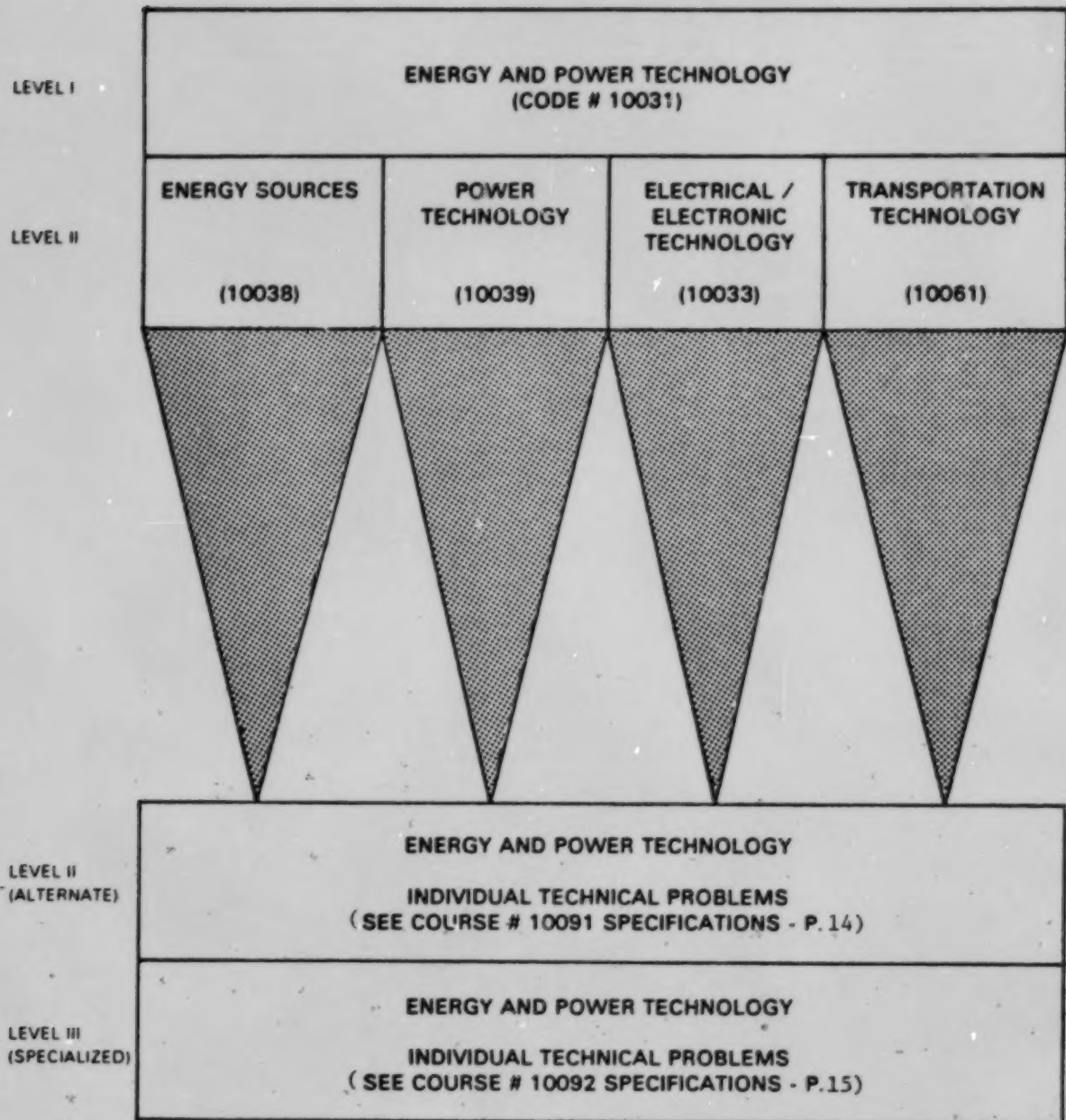
Also a broad treatment of the area of electricity/electronics necessitates gathering a fantastic variety of software, equipment, components and accessories seldom available at any price from one supplier.

Testimony that the above are significant obstacles to program development, is the fact that electricity/electronics courses in small high schools are almost non-existent in the state and elsewhere.

To summarize, the logistics, cost, and teacher upgrading requirements are such that the traditional electricity/electronics program is unrealistic for many schools. Therefore, it is suggested that rather than abandon the possibility of offering a program or course and the advantages it has to offer, one should consider abandoning traditional concepts of a proper program and begin with what one has available locally and build from those ideas presented in this guide.

In terms of equipment, one can begin with as little as a volt-ohm-milliammeter. In terms of supplies, again one should think locally, sources such as Radio Shack stores, state surplus, local manufacturing firms and parts salvaged from electronic devices brought in by students.

While this unit outline is useable for any program, the activities suggested are intended to permit the introduction of a course with little equipment or materials.



Sample Program Model

## INDIVIDUAL TECHNICAL PROBLEMS

COURSE CODE: 10091

This individual technical problem course is designed for students who have not had the opportunity to enroll in specific Level II subject matter courses in the Energy/Power Technology cluster area. The course is designed to provide a means for meeting individual student needs through the offering of multiple activities in a number of technical areas in schools where separate courses are not available.

|                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>INDUSTRIAL ARTS PURPOSE</b><br><br>Personal Enrichment<br><br>Pre-Technical | <b>SELECTED STUDENT COMPETENCIES</b><br><br>NOTE: Individual student competencies and learning experiences are to be identified and developed on a contractual basis by the student and approved by the instructor for each problem.<br><br><b>SAMPLE LEARNING TOPICS</b><br><br>NOTE: Learning topics for the ITP are to be selected from the instructional units identified for each specific subject matter course. These courses include:<br><br><b>ENERGY/POWER:</b><br>-- Energy Sources, 10038<br>-- Power Technology, 10039<br>-- Electrical/Electronic Technology, 10033<br>-- Transportation Technology, 10061 |
| <b>GRADE LEVEL</b><br><br>11 - 12                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>COURSE LENGTH</b><br><br>One period per day<br><br>18 or 36 weeks           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>UNIT OF CREDIT</b><br><br>1/2 or 1 unit                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>RECOMMENDED PREREQUISITES</b><br><br>Level I Curriculum Courses             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## INDIVIDUAL TECHNICAL PROBLEMS: ENERGY/POWER

COURSE CODE 10092

This individual technical problems course is designed for students who have had the Level II preliminary course of this cluster in the chosen area of study and intend to study specific advanced topic(s) in energy sources, power technology, electrical/electronic technology and/or transportation technology.

| INDUSTRIAL ARTS PURPOSE                               | SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Personal Enrichment<br>Pre-Technical                  | <p>Instruction in this industrial arts course is open to meet students needs. The following suggested objectives are meant to provide ideas for developing the student's program.</p> <ol style="list-style-type: none"><li>1. To prepare students for seeking advanced education in the area of energy/power.</li><li>2. To provide students the experiences in problem-solving, research and development, and technical report writing with regard to any chosen topic in energy/power.</li><li>3. To provide students with opportunities for exploration in energy/power systems and the practical application of scientific principles related to these systems.</li><li>4. To provide students with a broader understanding of career opportunities in energy/power.</li></ol> |
| GRADE LEVEL<br>11 - 12                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| COURSE LENGTH<br>One period per day<br>18 or 36 weeks |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| UNIT OF CREDIT<br>$\frac{1}{2}$ or 1 unit             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| RECOMMENDED PREREQUISITES<br>See Course Description   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

## **INDIVIDUAL TECHNICAL PROBLEMS:**

### **ENERGY/POWER**

#### **SAMPLE LEARNING UNITS**

##### **ENERGY SOURCES:**

- I. Gasahol Production
- II. Solar Heating and/or Cooling
- III. Solar Photovoltaic Banks
- IV. Wind or Water Energy Conversion Systems
- V. Energy Storage Systems

##### **POWER TECHNOLOGY:**

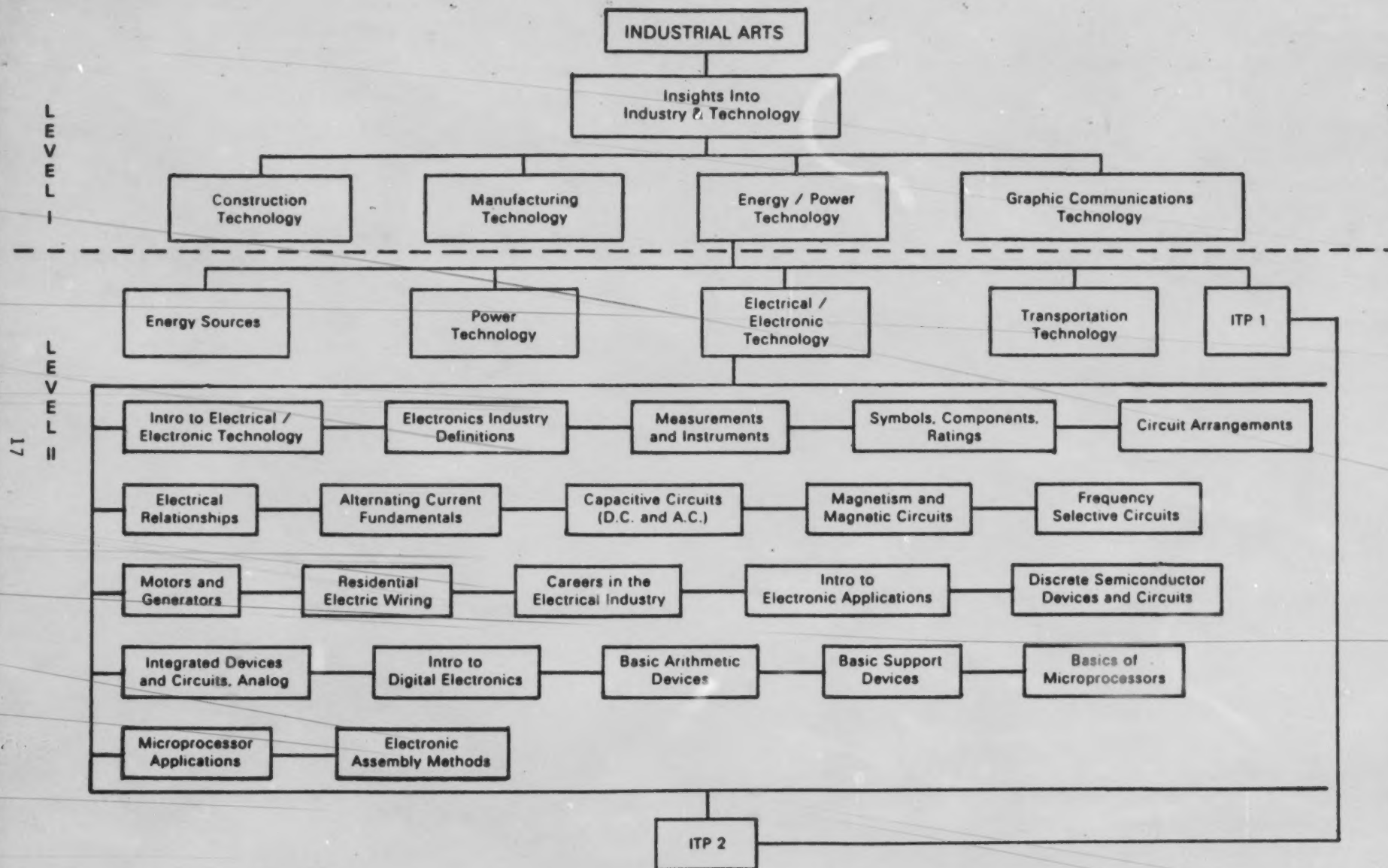
- I. Stirling Engine/Heat Pump
- II. Steam Engine
- III. Dynamometers for System Analysis
- IV. Hydraulic/Pneumatic Controls

##### **ELECTRICAL/ELECTRONIC TECHNOLOGY:**

- I. Amateur Radio
- II. Alarm Systems
- III. Trouble Shooting Communications Equipment
- IV. Vehicular and Other Microprocessor Control Units

##### **TRANSPORTATION TECHNOLOGY:**

- I. Electrical Vehicle Propulsion
- II. Linear Induction Motor Propulsion
- III. Air Suspension Systems



## **ELECTRICAL/ELECTRONIC TECHNOLOGY**

COURSE CODE: 10033

This course is designed to provide the student with an experimental introduction to basic electrical relationships, circuits and components and to modern electronic devices and circuits, with emphasis on practical applications.

| INDUSTRIAL ARTS PURPOSE                         | SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Personal Enrichment<br>Pre-Technical            | <p>Experiences and activities in this industrial arts course should enable the student to:</p> <ol style="list-style-type: none"><li>1. Use electrical terms in conversation and writing.</li><li>2. Explain basic electrical relationships.</li><li>3. Read schematic diagrams and recognize electrical/electronic symbols, components and packages; also assemble simple experimental circuits.</li><li>4. Use basic electrical/electronic test instruments and interpret significance of readings.</li><li>5. Apply electrical knowledge to everyday situations.</li><li>6. Demonstrate safe electrical/electronic circuit and equipment handling practices.</li><li>7. Demonstrate residential wiring procedures.</li><li>8. Demonstrate basic electronic fabrication techniques.</li><li>9. Identify and select appropriate motors, generators and/or components for specific practical applications.</li><li>10. Explain basic semiconductor theory.</li><li>11. Explain operation of basic discrete semiconductor devices.</li><li>12. Explain how discrete and integrated devices are fabricated.</li><li>13. Construct basic circuits combining discrete active, passive and/or integrated devices.</li><li>14. Explain the basic operation of common analog electronic circuits.</li><li>15. Explain the basic operation of common digital circuits.</li><li>16. Identify circuits and devices used in everyday appliances, equipment, and personal conveniences.</li><li>17. Explain the scope and impact of the electronics revolution on his or her life and on society.</li></ol> |
| GRADE LEVEL                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 10 - 12                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| COURSE LENGTH                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| One period per day<br>18 or 36 weeks            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| UNIT OF CREDIT                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| $\frac{1}{2}$ or 1 unit                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| RECOMMENDED PREREQUISITES                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Freshman Algebra or Permission<br>of Instructor |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

**ELECTRICAL / ELECTRONIC TECHNOLOGY**

**Suggested Instructional Units**

|                                                          | Class Periods |          |
|----------------------------------------------------------|---------------|----------|
|                                                          | (18 wks)      | (36 wks) |
| I. Introduction to Electrical/Electronic Technology      | 2             | 3        |
| II. Electronics Industry Definitions                     | 1             | 3        |
| III. Measurements and Instruments                        | 3             | 5        |
| IV. Symbols, Components, Ratings                         | 2             | 3        |
| V. Circuit Arrangements                                  | 5             | 10       |
| VI. Electrical Relationships                             | 5             | 10       |
| VII. Alternating Current Fundamentals                    | 5             | 10       |
| VIII. Capacitive Circuits (D-C and A-C)                  | 5             | 13       |
| IX. Magnetism and Magnetic Circuits                      | 5             | 12       |
| X. Frequency Selective Circuits                          | 0             | 10       |
| XI. Motors and Generators                                | 10            | 15       |
| XII. Residential Electrical Wiring                       | 5             | 10       |
| XIII. Careers in the Electrical Industry                 | 2             | 3        |
| XIV. Introduction to Electrical Applications and Careers | 2             | 3        |
| XV. Discrete Semiconductor Devices and Circuits          | 10            | 15       |
| XVI. Integrated Devices and Circuits, Analog             | 5             | 10       |
| XVII. Introduction to Digital Electronics                | 8             | 10       |
| XVIII. Basic Arithmetic Devices                          | 0             | 10       |
| XIX. Basic Support Devices                               | 5             | 10       |

|                                            |          |          |
|--------------------------------------------|----------|----------|
| XX. Microprocessor Basics and Applications | 10       | 15       |
| XXI. Electronic Assembly Methods           | <u>*</u> | <u>*</u> |
| TOTAL                                      | 90       | 180      |

\*This unit is optional (see explanatory notes within unit). This unit's content may be used as a "filler" if some spare class periods become available. However, no more than 10 class periods should be used. It may also be used for individual/independent, late afternoon, or evening student activity.

## UNIT I

### Introduction to Electrical/Electronic Technology

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An introduction to electrical safety procedures.
2. Brief information on career opportunities available in the electrical/electronic industries.
3. A perception of the impact of the electrical/electronic industries on the individual and society.

#### 1.0.0 Safety

##### 1.1.0 Nature of electricity

- 1.1.1 The atom, protons, neutrons, electrons
- 1.1.2 Atomic number and the valence bond
- 1.1.3 Properties of a conductor
- 1.1.4 Properties of an insulator
- 1.1.5 Properties of a semiconductor

##### 1.2.0 Effect of electricity on the human body

##### 1.3.0 Safety procedures

##### 1.4.0 Safety systems

- 1.4.1 Grounding equipment
- 1.4.2 2-wire system
- 1.4.3 3-wire system
- 1.4.4. Double insulating system
- 1.4.5 Ground fault interrupters

#### 2.0.0 Occupational Information

##### 2.1.0 Careers in electricity

##### 2.2.0 Careers in electronics

##### 2.3.0 Vocational opportunities through education

##### 2.4.0 Professional opportunities through education

##### 2.5.0 Consumer information

## UNIT I

### 3.0.0 Scope of Industry Impact

3.1.0 Impact on industry

3.2.0 Impact on society

3.3.0 Impact on individual

3.4.0 Impact on environment

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT I: Introduction to Electrical/Electronic Technology**

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                     | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</b></p>                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                              |
| <p>A. List parts of the atom and their functions and relate these to the characteristics of conductors, insulators, and semiconductors.</p>                                                                       | <p>A.1 Have students read and participate in classroom discussion regarding the makeup of atoms, materials used in conductors, insulators, and semiconductors.</p>                                                                                                                                                                                                           |
| <p>B. Identify a variety of safety procedures and systems and explain why they are important in the laboratory and elsewhere.</p>                                                                                 | <p>B.1 Have students assist the instructor in surveying the laboratory with the intent of identifying any safety hazards, of becoming familiar with the safety systems which are in use, and of recommending improvements toward a safe environment.</p>                                                                                                                     |
| <p>C. Identify a variety of careers associated with the electrical industry and discuss, verbally or in writing, the duties/responsibilities, and education needed for employment in those careers.</p>           | <p>C.1 Have students, individually or in small groups, choose a particular career category, then read about and interview individuals in that career, and then report the findings to the class.</p>                                                                                                                                                                         |
| <p>D. Describe how one or more inventions or devices used in or associated with the electrical industry has effected the individual, society, industry, and/or the environment, positively and/or negatively.</p> | <p>D.1 Have students read, research, report, and discuss the history of one or more electrical industry devices or machines regarding its various impacts.</p> <p>D.2 Have students view films or listen to guest lecturers (electrician, utility company representative, etc.) regarding safety, careers, and the industry's impact. (Also apply to B.1 and C.1 above).</p> |

## UNIT II:

### Electronics Industry Definitions

#### OBJECTIVES:

This unit is meant to provide the student with common conceptual distinctions important in developing a perspective of the entire field of electrical/electronic technology.

#### 1.0.0 Definition of Electricity

1.1.0 Examples of common devices

1.2.0 Examples of common applications

#### 2.0.0 Definition of Electronics

2.1.0 Examples of common devices

2.2.0 Examples of common applications

#### 3.0.0 Definition of D.C. Circuits

3.1.0 Examples of common D.C. circuits

3.2.0 Examples of D.C. circuit applications

#### 4.0.0 Definition of A.C. Circuits

4.1.0 Examples of common A.C. circuits

4.2.0 Examples of A.C. circuits applications

#### 5.0.0 Definition of Passive Devices

5.1.0 Examples of passive devices and circuits

5.2.0 Examples of passive circuit applications

#### 6.0.0 Definition of Active Devices

6.1.0 Examples of active devices

6.2.0 Examples of active device applications

#### 7.0.0 Definition of Discrete Circuits

7.1.0 Examples of common discrete devices for circuits

7.2.0 Examples of common discrete circuit applications

## UNIT II

### 8.0.0 Definition of Integrated Circuit

8.1.0 Examples of common integrated circuit/devices

8.2.0 Examples of common integrated circuit applications

### 9.0.0 Definition of Analog Electronics

9.1.0 Examples of common devices

9.2.0 Examples of common applications

### 10.0.0 Definition of Digital Electronics

10.1.0 Examples of common devices

10.2.0 Examples of common applications

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT II: Electronics Industry Definitions**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                             | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <ul style="list-style-type: none"> <li>A. Distinguish between and identify differences as well as commonalities of various categories of electrical and electronic technology.</li> <li>B. Identify various pieces, equipment, machines, or devices as belonging in one or more of the categories of electrical and electronic technology.</li> </ul> | <ul style="list-style-type: none"> <li>A.1 Have students read about, discuss, and report to the class their conclusions regarding various categories of electrical and electronic technology.</li> <li>B.1 Have individual students choose pieces of equipment, machines, and/or devices and then visually inspect or read literature about it and then decide as to why it belongs in one or more of the categories of electrical and electronic technology.</li> </ul> |

## UNIT III

### Measurements and Instruments

#### OBJECTIVES:

This unit is meant to provide the student with basic concepts and units which are prerequisite to a study of electrical relationships.

#### 1.0.0 Metric System

- 1.1.0 Metric system multiple prefixes
- 1.2.0 Metric system submultiple prefixes
- 1.3.0 Conversion problems from one multiple or submultiple to another

#### 2.0.0 Aspects of Current Flow

- 2.1.0 Convention current flow theory
- 2.2.0 Electron current flow theory
- 2.3.0 Electron impulse (speed of)
- 2.4.0 Electron charge: the coulomb
- 2.5.0 Electron flow: coulombs per second (ampere)
- 2.6.0 Electron measuring device: the ammeter
- 2.7.0 Electron flow measurement: the series connection

#### 3.0.0 Voltage - Pressure

- 3.1.0 The unit of electrical pressure - the volt
- 3.2.0 Voltage rises - voltage (pressure) sources
- 3.3.0 Voltage drops - voltage (pressure) lessens
- 3.4.0 Voltage measuring devices - the voltmeter
- 3.5.0 Voltage measurement - the parallel connection
- 3.6.0 Kirchhoff voltage law.

#### 4.0.0 Resistance - Opposition to flow

### UNIT III

- 4.1.0 Unit of resistance - the ohm
- 4.2.0 Types of resistors
- 4.3.0 The resistor color code
- 4.4.0 Resistance measuring device - the ohmmeter
- 4.5.0 Resistance measurement
- 5.0.0 Energy - Work Ability
  - 5.1.0 Work = force x distance
  - 5.2.0 Energy = force x distance (ability)
  - 5.3.0 Metric mechanical units
  - 5.4.0 Power is a rate of work, or  $P = \text{work/time}$
  - 5.5.0 Metric unit of power - the watt
  - 5.6.0 English unit of power - the horsepower
  - 5.7.0 Power measuring device - the wattmeter
  - 5.8.0 Energy measuring device - the watt-hour meter

3

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT III: Measurements and Instruments**

**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

- A. Become familiar with and reasonably proficient in the use of metric system prefixes, multiples, and submultiples.
- B. Identify and distinguish between the basic electrical measurands of current, voltage, resistance, power and energy. Become familiar with the basic and typically used prefixes associated with each.
- C. Become familiar with and proficient in the use of the resistor color code.
- D. Become familiar with and proficient in using the ammeter, voltmeter, and ohmmeter in making simple measurements.

- A.1 Through instructor lecture and class discussion, have students practice converting quantities from one prefix representation to another.
- B.1 Have students use the basic electrical measurements in class discussions and in writing toward showing a proficiency in using prefix representations for these measurements.
- C.1 Have students make simple, basic measurements of current flow, voltage and resistance, using a VOM, or other multimeter, and properly record the measurements using the most appropriate prefixes. In the case of resistance measurements, have students use the correct color code.
- D.1 (See C.1 above)

## UNIT IV

### Symbols, Components, Ratings

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of methods by which the fundamental electrical/electronic components are symbolized in relation to their physical appearance.
2. An understanding of the categories under which fundamental electrical/electronic components are rated, and the meaning of these ratings.
3. Experience in choosing the correct components of correct ratings as specified in simple electrical schematics.

#### 1.0.0 Resistances: Symbols and Ratings

- 1.1.0 Types: carbon, wirewound, fixed, variable, etc.
- 1.2.0 Ohmic rating
- 1.3.0 Tolerance rating
- 1.4.0 Color code
- 1.5.0 Power rating

#### 2.0.0 Voltage Sources: Symbols and Ratings

##### 2.1.0 Direct-current

- 2.1.1 Voltage and current specified
- 2.1.2 Primary and secondary cells
- 2.1.3 Storage: fixed value
- 2.1.4 Continuous: fixed value
- 2.1.5 Continuous: variable value

##### 2.2.0 Alternating-current

- 2.2.1 Voltage, current, and/or frequency specified
- 2.2.2 Fixed value
- 2.2.3 Variable value

#### 3.0.0 Connectors and Connections: Symbols and Meanings

##### 3.1.0 Connectors (removeable)

- 3.1.1 Polarized versus non-polarized
- 3.1.2 Voltage and/or current ratings

## UNIT IV

### 3.2.0 Connections (fixed) versus crossover

3.2.1 Schematic dotted and crossed intersection

3.2.2 Schematic tee and aligned intersection

### 4.0.0 Controls

#### 4.1.0 Switching controls: symbols and ratings

4.1.1 "Poles" and "throws" of switches

4.1.2 "Poles" and "positions" of rotary switches

4.1.3 Shorting versus non-shorting

4.1.4 Voltage and/or current and AC/DC ratings

#### 4.2.0 Continuously-variable controls: symbols and ratings

4.2.1 Types: carbon, wirewound, degrees of rotation, etc.

4.2.2 Linear versus nonlinear

4.2.3 Potentiometer versus rheostat connections

4.2.4 Voltage and/or current and power ratings

4.2.5 Mechanical ganging connections

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT IV: Symbols, Components, Ratings**

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**SELECTED STUDENT COMPETENCIES**

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**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

- A. Become familiar with the basic symbols of passive devices, and variation thereof, used in electrical technology (and later in electronic technology) and the components and ratings which they represent.

**SAMPLE LEARNING ACTIVITIES**

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- A.1 Have students choose one or more of a variety of passive circuit schematics (of actual or fictitious use) and then choose the resistors of correct ratings and arrange them in the form shown in the schematic. After instructor inspection and approval of the student's work, have the student return the resistors to their original location to further reinforce understanding of the components' identity.
- A.2 Repeat an exercise similar to A.1 above using other passive components such as voltage sources, connectors, controls, capacitors, and inductors.
- A.3 Repeat an exercise similar to A.1 above using schematics having a "mixture" of passive components.

## UNIT V

### Circuit Arrangements

#### OBJECTIVES:

This unit is meant to provide the student with a knowledge of common circuit arrangements.

- 1.0.0 Definition of a Series Circuit
  - 1.1.0 Series sources
  - 1.2.0 Series loads
  - 1.3.0 Review Kirchhoff's voltage law
- 2.0.0 Definition of a Parallel Circuit
  - 2.1.0 Parallel sources
  - 2.2.0 Parallel loads
  - 2.3.0 Review Kirchhoff's current law
- 3.0.0 Comparison of Series and Parallel Circuits
  - 3.1.0 Common element of a series circuit
  - 3.2.0 Common element of a parallel circuit
- 4.0.0 Combination Circuits
  - 4.1.0 Solving simple combination circuits
  - 4.2.0 Examples of combination circuits

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT V: Circuit Arrangements**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

Note to Instructor: Often students' understanding of voltage rise and drop and of current-flow division and recombination can be more easily accomplished without immediately using the concepts of total circuit resistance and Ohm's Law, which are covered in the next unit. Therefore, only the Kirchhoff Law concepts are presented in this unit.

- A. Become familiar with the characteristics of series, parallel, and series-parallel circuits and how Kirchhoff's Laws apply to each.
  
- B. Write Kirchhoff equations for simple circuits using both symbolic form, e.g.,  $V_1 + V_2 + V_3 - V_S = 0$ , and using numerical values.
  
- C. Properly use the ammeter and the voltmeter to make measurements toward verification of Kirchhoff's Laws.

A.1 Have students write Kirchhoff voltage equations for various circuit loops and current equations for various points, or nodes, using simple circuits and problems from textbooks or other sources.

B.1 Have students write the Kirchhoff voltage and current equations in symbolic form for a variety of circuits which can later be analyzed in the laboratory.

C.1 In the laboratory have students connect the circuits used in B.1 above, then properly measure the magnitude and polarity of voltages and currents, and then

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT V: Circuit Arrangements**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:

substitute these measured  
values into the symbolic  
equations (combine like  
terms to reduce the equa-  
tions) thereby verifying  
Kirchhoff's voltage and  
current laws.

## UNIT VI

### Electrical Relationships

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of fundamental electrical laws as applied to simple circuits.
2. Experience in verifying fundamental electrical laws via comparing measured values with calculated values.

#### 1.0.0 Ohm's Law

##### 1.1.0 Definition of concepts

- 1.1.1 Current: flows through
- 1.1.2 Voltage: exists across
- 1.1.3 Resistance: a property of or in the circuit

##### 1.2.0 Verification

- 1.2.1 Fixed voltage: current inversely proportional to resistance
- 1.2.2 Fixed resistance: current directly proportional to voltage

#### 2.0.0 Electrical Power

##### 2.1.0 Definition of power and watt

- 2.1.1 Voltage: the movement-causing force
- 2.1.2 Current: the rate of charge movement
- 2.1.3 Watts = volts x amperes
- 2.1.4 Other power formulas

##### 2.2.0 Verification

#### 3.0.0 Series Circuit Relationships

##### 3.1.0 Total resistance = summated resistances

##### 3.2.0 Total power = summated powers

#### 4.0.0 Parallel Circuit Relationships

##### 4.1.0 Conductance = reciprocal of resistance

##### 4.2.0 Total conductance = summation of conductances

##### 4.3.0 Total resistance = reciprocal of total conductance

##### 4.4.0 Total power = summated powers

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT VI: Electrical Relationships**

**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:

- A. Express Ohm's Law verbally and in writing, properly using the three essential concepts within this law.
  
- B. Use the various equations to determine, and to reflect an understanding of, the power dissipated in individual components and in an entire circuit.
  
- C. Both theoretically and experimentally analyze the electrical parameters (voltages, currents, resistance, and power values) of series, parallel, and series-parallel resistive circuits.

- A.1 Have students use Ohm's Law to solve for the unknown numerical value(s) of simple circuits and then write separate statements properly expressing the relationship of these values(s) to the circuit.
  
- A.2 In the laboratory have students connect specific circuits and make measurements which verify that
  - a) current flow is inversely proportional to resistance
  - and b) current is directly proportional to voltage.
  
- B.1 Have students solve for values of power dissipated in various portions of circuits, preferably those circuits used in laboratory experimentation.
  
- C.1 In the laboratory have students assemble specific series, parallel, and series-parallel circuits and measure the various current, voltage, and resistance parameters. Then have students select some of these parameters and calculate the theoretical values and compare them with the measured values.

## UNIT VII

### Alternating Current Fundamentals

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of fundamental concepts peculiar to alternating current.
2. An understanding of A-C terminology.
3. An understanding of A-C measurement and display.

#### 1.0.0 Alternating Current Fundamentals

- 1.1.0 The sine-wave, alternation, cycle, and period
- 1.2.0 Peak or maximum values of voltage and current
- 1.3.0 Peak-to-peak values
- 1.4.0 Average value in AC versus DC
- 1.5.0 The RMS or DC-equivalent value
- 1.6.0 Conversion factors

#### 2.0.0 Alternating Current Measurement and Display

- 2.1.0 Amplitude: RMS, peak, peak-to -peak, and instantaneous values
- 2.2.0 Frequency and time relationships
- 2.3.0 Phase relationships of two signals

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT VII: Alternating Current Fundamentals**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

Note to Instructor: All except some specialized A-C meters can measure RMS values of sine-wave voltages and many have scales with peak-to-peak values. However, to show (display) and/or measure frequency, time, and phase relationships; an oscilloscope is the minimal piece of equipment.

- A. Express verbally, in writing, and/or in sketches, the various fundamental concepts related to sine-wave alternating current.
- B. Perform various conversion of values associated with sine-wave alternating current.
- C. Properly make measurements with meter and/or oscilloscope, of alternating current parameters and express these measurements and their interrelationships in a meaningful way.

- A.1 Have students participate in discussions about and write and/or sketch solutions to questions and problems regarding sine-wave alternating current.
- B.1 Have students convert values from one base to another, e.g., from RMS to peak-to-peak, for theoretical circuits as well as for those used in the laboratory (See C.1 below).
- C.1 In the laboratory have students assemble specific circuits and measure various parameters using an A-C Voltmeter, ammeter, and/or oscilloscope and then express these measured values in a proper and meaningful way.

## UNIT VIII

### Capacitive Circuits (D-C and A-C)

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of capacitor functions in A-C and D-C circuits.
2. An understanding of the phase relationships in capacitive circuits.
3. Capacitor circuit arrangements and the resultant effects.

#### 1.0.0 D-C Circuit Capacitor Function

1.1.0 Electrostatic (charge) storage

1.2.0 Mechanical analogies: the spring; the air accumulator

#### 2.0.0 Resistor-Capacitor D-C Circuits

2.1.0 The RC time constant concept

2.2.0 Capacitor voltage change versus time

2.3.0 Circuit current (and resistor voltage) change versus time

#### 3.0.0 Capacitor Circuit Arrangements

3.1.0 Series connection: resultant capacitance and voltage division

3.2.0 Parallel connection: resultant capacitance and current (charge flow) division

3.3.0 Series-parallel connection: resultant capacitance, voltage, and current relationships

#### 4.0.0 Resistor-Capacitor A-C Circuits

4.1.0 Capacitive reactance: definition and examples

4.2.0 Impedance: definitions and examples

4.3.0 Ohm's Law application

4.4.0 I-V phase relationship

4.5.0 Real power versus apparent power

4.6.0 Applications of RC A-C circuits

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT VIII: Capacitive Circuits (D-C and A-C)**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                   | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <p>A. Understand and express the relationships of stored charge, capacitance, and voltage of a charged capacitor.</p> <p>B. Understand and express, verbally, in writing, and/or mathematically, the charge/discharge characteristics of simple D-C powered resistor--capacitor circuits, and how these characteristics relate to applications such as wave-form generators and timers.</p> | <p>A.1 &amp; B.1 Have students read, participate in discussions, and solve problems involving simple capacitor and resistor-capacitor circuits and applications.</p> <p>A.2 &amp; B.2 In the laboratory have students assemble simple R-C circuits, and simple timing circuits, such as, neon-bulb flashing and/or unijunction transistor metronome circuits, and make appropriate measurements toward understanding the charge/discharge characteristics of capacitors.<br/>Note: Long time constant (1 second or longer) circuits may be analyzed using a high input resistance voltmeter, while short time constant circuits are best analyzed with an oscilloscope.</p> |

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT VIII: Capacitive Circuits (D-C and A-C)**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:

C. Express in writing and verbally the electrical parameters resulting from circuits containing capacitors connected in series and/or parallel.

C.1 Have students read, participate in discussions, and solve problems involving simple circuits containing capacitors connected in series and/or parallel.  
Note: For any series connection of capacitors measured voltages will be sustained if the circuit is powered by an A-C source, but not when using a D-C source.

D. Understand and use the concepts of capacitive reactance, impedance, phase angle, and power related to simple A-C powered resistor-capacitor circuits, and realize some of the applications of such circuits.

D.1 Have students read, participate in class discussions, and solve simple problems involving A-C powered R-C circuits.

D.2 In the laboratory have students make appropriate measurements of voltages and current in series R-C circuits and of voltage and currents in parallel R-C circuits using a multimeter. Phase angle measurements can be made using an oscilloscope. It is advisable to use circuits for which parameters have been calculated by the students (See D.1 above).

## UNIT IX

### Magnetism and Magnetic Circuits

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of the principles of magnets, electromagnetism and magnetic circuits and laws.
2. Information concerning the numerous applications of magnetic devices and circuits in both D-C and A-C situations.

#### 1.0.0 Permanent Versus Electro Magnetism

##### 1.1.0 Core materials

##### 1.2.0 Flux density-magnetizing force characteristics

#### 2.0.0 Applications: With D-C and A-C Ratings

##### 2.1.0 Relays

##### 2.2.0 Solenoids

#### 3.0.0 Inductance and Electromagnetic Induction

##### 3.1.0 Induction principles and results

##### 3.2.0 A-C inductive reactance: definition and examples

###### 3.2.1 Resistor-inductor A-C circuits

###### 3.2.2 Impedance: definition and examples

###### 3.2.3 Ohm's Law application

###### 3.2.4 I-V phase relationship

###### 3.2.5 Real power versus apparent

###### 3.2.6 Applications of RL A-C circuits

##### 3.3.0 Series and parallel inductor arrangements

##### 3.4.0 Induction device applications

###### 3.4.1 Transformers: types and ratings

###### 3.4.2 Ignition coil and circuit operation

###### 3.4.3 Pulse generators and sensors

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT IX: Magnetism and Magnetic Circuits**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
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| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <ul style="list-style-type: none"> <li>A. Understand and discuss the characteristics of magnets, electromagnetism, and magnetic circuits.</li> <li>B. Distinguish between various types (and the ratings) of electromagnetic devices and to properly connect and use such devices in simple circuit applications.</li> <li>C. Understand and express, verbally, in writing and/or mathematically, the basic functioning of magnetic circuits.</li> <li>D. Understand and use the concepts of inductive reactance, impedance, phase angle, and power related to simple A-C powered resistor-inductor circuits, and realize some of the applications of such circuits.</li> </ul> | <ul style="list-style-type: none"> <li>A.1 Have students read, participate in class discussions, and conduct simple experiments using permanent magnets and low-voltage A-C powered electromagnets.</li> <li>B.1 In the laboratory have students become familiar with manufacturers' ratings of electromagnetic devices and then use those devices in experiments so as to verify their ratings and functions.</li> <li>C.1 (See B.1; above)</li> <li>D.1 Have students read, participate in class discussions, and solve simple problems involving A-C powered resistor-inductor circuits.</li> </ul> |

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT IX: Magnetism and Magnetic Circuits**

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| SELECTED STUDENT COMPETENCIES                                    | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</p> | <p>D.2 In the laboratory have students make appropriate measurements of voltage(s) and current(s) using a multimeter. Phase angle measurements may be made using an oscilloscope. It is advisable to use circuits for which students have previously calculated electrical parameters so as to permit comparison of theoretical and measured values.</p> |

## UNIT X

### Frequency Selective Circuits

#### OBJECTIVES:

This unit meant to provide the student with:

1. An understanding of the types, classifications, and operational characteristics of frequency selective circuits.
2. Information on the numerous applications of frequency selective circuits.

#### 1.0.0 Fundamental Concepts

##### 1.1.0 Attenuation

##### 1.2.0 Center, cutoff, and resonant frequency

##### 1.3.0 Bandwidth, figure of merit

##### 1.4.0 Frequency response: definition and representational methods

#### 2.0.0 RL and/or RC Filter Circuit Characteristics

##### 2.1.0 Low-pass circuits and applications

##### 2.2.0 High-pass circuits and applications

##### 2.3.0 Band-stop circuits and applications

##### 2.4.0 Band-pass circuits and applications

#### 3.0.0 LC Tuned Circuit Characteristics

##### 3.1.0 Series resonant circuits and applications

##### 3.2.0 Parallel resonant circuits and applications

##### 3.3.0 Double-tuned circuits and applications

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT X: Frequency Selective Circuits**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                         | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <p>A. Become familiar with the various types of frequency selective circuits, their functional characteristics, and the basic formulas which describe those characteristics.</p> <p>B. Understand and discuss some of the general and specific uses of frequency selective circuits in commonly used devices.</p> | <p>A.1 Have students read, participate in class discussions, and solve simple problems regarding various types of frequency selective circuits.</p> <p>A.2 In the laboratory have students conduct experiments on various circuits toward identifying their frequency response. These circuits might be those analyzed in problems under A.1 &amp; B.1 above. <u>Note:</u> Minimal equipment items for these experiments include a variable-frequency (audio and/or radio frequency) generator and a high-quality multimeter or an oscilloscope.</p> <p>B.1 (See A.1; above)</p> <p>B.2 Provide students with schematics of AM and FM radios, stereos, TV sets or other equipment and have them locate various groups of components which function as frequency selective circuits and, if possible, identify the type of circuit involved. This activity does <u>not</u> require the students to understand the entire schematic.</p> |

## UNIT XI

### Motors and Generators

#### OBJECTIVES:

This unit is meant to provide the student with:

1. The fundamental electrical concepts and physical construction characteristics of various motors and generators.
2. An understanding of the performance characteristics, ratings, applications, and methods of analysis applicable to various motors and generators.

#### 1.0.0 Basic Generator Concepts

- 1.1.0 Conductor magnetic flux cutting
- 1.2.0 Faraday's Law
- 1.3.0 Right-hand rule application
- 1.4.0 Basics of sine-wave generation
- 1.5.0 Generator parts, purposes, and arrangements

#### 2.0.0 Basic Motor Concepts

- 2.1.0 Force on conductor within flux path
- 2.2.0 Right-hand rule application
- 2.3.0 Motor parts, purposes, and arrangements
- 2.4.0 Motor classifications and ratings
  - 2.4.1 Power ratings and duty cycle
  - 2.4.2 Environmental considerations
  - 2.4.3 Speed: full-load and no load
  - 2.4.4 Starting methods and circuitry
  - 2.4.5 Torque characteristics

#### 3.0.0 D-C Motors and Generators

- 3.1.0 Types and specific ratings and characteristics
- 3.2.0 Input/output performance analysis
- 3.3.0 Specific applications

## UNIT XI

### 4.0.0 A-C Single-Phase Motors and Generators

4.1.0 Types and specific ratings and characteristics

4.2.0 Input/output performance analysis

4.3.0 Specific applications

### 5.0.0 A-C Poly-Phase Motors and Generators

5.1.0 Types and specific ratings and characteristics

5.2.0 Input/output performance analysis

5.3.0 Specific applications

## Electrical/Electronic Technology

## SAMPLE LEARNING ACTIVITIES

C.1 In the laboratory have students conduct simple tests, such as speed versus load, i.e., current draw, of various small motors and terminal voltage versus load in amperes of generators and/or alternators. Various sources contain information on equipment needed for such tests.

## UNIT XII

### Residential Electrical Wiring

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of the principles involved in residential wiring toward achieving proper load distribution, safety assurance, and convenience.
2. Information regarding components, adherence to design specifications, and the meanings of national, state, and local wiring codes.

#### 1.0.0 Safety

1.0.0 Wiring codes: purposes and meanings

1.2.0 Grounding methods

1.3.0 Circuit protection devices

1.4.0 Electrical terminal location standards

1.5.0 Wire, circuit, and fixture ampere-capacity standards

#### 2.0.0 Load Distribution Principles

2.1.0 230 Volt appliance and wiring standards

2.2.0 115 Volt circuit wiring standards

2.3.0 Standards toward balancing the two 115-volt circuits

2.4.0 Auxiliary systems/appliance wiring standards

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT XII: Residential Electrical Wiring**

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                         | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <p>A. Understand and express verbally, diagrammatically, and/or in writing the principles of safety, load distribution, etc., involved in residential wiring.</p> | <p>A.1 Have students read, participate in class discussions, and solve materials/components selection and wiring design problems.</p> <p>A.2 In the laboratory have students conduct simple experiments involving the balancing of loads on a three-wire system using components typically used for teaching electrical technology. A low-voltage center-tapped transformer, e.g., 12.6 Va-c, CT an assortment of pilot lamps, e.g., 6.3. and 12.6 volt rating, and a multimeter capable of measuting A-C voltage and current are needed.</p> <p>A.3 Have students interview, or listen to and discuss with, a guest speaker such as an electrician or electrical contractor to obtain information on topics contained in the course outline.</p> |

SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR

Electrical/Electronic Technology

UNIT XII: Residential Electrical Wiring

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                   | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</p> <p>B. Properly interpret national,<br/>state, and local electrical<br/>codes and design specifica-<br/>tions and apply them in<br/>actual and/or simulated<br/>electrical wiring problems.</p> | <p>B.1 In the laboratory have<br/>students do residential<br/>electrical wiring using<br/>actual components and<br/>materials on wall/ceiling<br/>sectional constructions or<br/>using small components and<br/>materials and a low-voltage<br/>A-C source (See A.2 above)<br/>on a scale model house.</p> <p>B.2 (See A.3 above)</p> |

## UNIT XIII

### Careers in the Electrical Industry

#### OBJECTIVES:

This unit is meant to provide the student with information regarding:

1. The occupations and attendant responsibilities and duties in the electrical industry.
2. The training and educational preparations which may be needed or desirable toward employment in the electrical industry.

#### 1.0.0 Career Categories and Responsibilities/Duties

- 1.1.0 Research and development
- 1.2.0 Engineering
- 1.3.0 Technologist/technician
- 1.4.0 Electrician
- 1.5.0 Skilled worker
- 1.6.0 Semi-skilled worker
- 1.7.0 Laborer

#### 2.0.0 Educational and Training Programs/Opportunities

- 2.1.0 Applicable four-year college program fields
- 2.2.0 Applicable two-year program fields
- 2.3.0 Trades and industry fields programs
- 2.4.0 On-the-job training possibilities

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XIII: Careers in the Electrical Industry**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

- A. Identify a variety of occupations associated with the electrical industry and express verbally and in writing the significant responsibilities and duties of each.

- A.1 Have students do reading and research, participate in class discussions, conduct interviews, and listen to guest speakers, in order to understand the variety of occupations, and then write a report on selected occupation(s) associated with the electrical industry.

- A.2 Have students write letters to obtain information on various aspects of training or educational programs related to chosen occupation(s) in the electrical industry (also compare/contrast them). Report to the class or prepare a written report on the findings.

- B. Investigate, describe, and compare/contrast the training or educational preparations which are associated with specific categories or occupations in the electrical industry.

- B.1 (See A.1 above)

- B.2 (See A.2 above)

## UNIT XIV

### Introduction to Electronic Applications and Careers

#### OBJECTIVES:

This unit is meant to provide the student with information regarding:

1. Safety hazards and precautions applicable in the electronic industry, additional to those of Unit I.
2. Career and occupational fields applicable in the electronic industry, additional to those of Unit XIII.
3. The high rate of change of technology in the electronic industry, and its impact on society and the individual, beyond the coverage presented in Unit I.

#### 1.0.0 Electronic Safety Considerations

- 1.1.0 Grounding and shielding
- 1.2.0 Corona and ozone hazards/protection
- 1.3.0 High-frequency radiation hazards

#### 2.0.0 Career Categories, Responsibilities/Duties, and Preparations

- 2.1.0 Communications electronics fields
- 2.2.0 Data processing fields
- 2.3.0 Electronics education fields

#### 3.0.0 Scope of Electronic Age Impact

- 3.1.0 Impact on various industries
- 3.2.0 Impact on society
- 3.3.0 Impact on individuals
- 3.4.0 Impact on environment and ecology

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XIV: Introduction to Electronic Applications and Careers**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</b></p>                                                                                                                      |                                                                                                                                                                                                                                                                                                              |
| <p>A. Identify and describe various safety hazards and the safety and protective measures appropriate to each.</p>                                                                           | <p>A.1 Have students read, participate in class discussions, and/or view films. Prepare verbal or written reports regarding potential hazards when working with electronics or in the electronic industries and appropriate precautions, protective measures, and attitudes toward preventing accidents.</p> |
| <p>B. Identify and describe a variety of electronic industry careers with regard to the duties, responsibilities, and training or educational preparation needed for employment in each.</p> | <p>B.1 Have students read, conduct interviews, participate in class discussions, write information from industries, training, and educational centers. Prepare verbal or written class reports regarding careers associated with electronics.</p>                                                            |
| <p>C. Understand and discuss various aspects of the impact which electronic developments have had on society and segments thereof.</p>                                                       | <p>C.1 Have students view films, read, participate in class discussions, or visit an industry (manufacturing, TV station, telephone company, etc.) which make extensive use of electronics toward gaining an insight into the rapid rate of change in electronic technology.</p>                             |

## UNIT XV

### Discrete Semiconductor Devices and Circuits

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of the makeup and the device and circuit functional characteristics of various discrete semiconductors.
2. Experiences in conducting basic laboratory measurements toward understanding both the operational aspects and the uses of discrete semiconductor circuits.

#### 1.0.0 Basic Fabrication of Devices and Typical Biasing

##### 1.1.0 Basic P-N junction devices

##### 1.2.0 Bipolar transistors

##### 1.3.0 Field-effect transistors

##### 1.4.0 Unijunction transistors

##### 1.5.0 Three-junction (four layers) devices

#### 2.0.0 Diode functions

##### 2.1.0 Rectification and basic power supplies

##### 2.2.0 Voltage-variable capacitance

##### 2.3.0 Other

#### 3.0.0 Transistor Functions

##### 3.1.0 Amplifiers

##### 3.2.0 Oscillators

##### 3.3.0 Power controls: power supplies, switching, etc.

##### 3.4.0 Limiters and gating/amplifying

#### 4.0.0 Special Device Functions

## UNIT XV

- 4.1.0 Diacs
- 4.2.0 Silicon controlled rectifiers
- 4.3.0 Triacs
- 4.4.0 Light-dependent devices
- 4.5.0 Temperature-dependent devices
- 4.6.0 Optical couplers
- 4.7.0 Solid-state relays

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XV: Discrete Semiconductor Devices and Circuits**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

- A. Visualize and describe the physical structure of and manufacturing process by which various semiconductor devices are fabricated.
- B. Understand and describe the functional characteristics, use the basic formulas, and make experimental measurements on various semiconductor diode circuits.
- C. Understand and describe the functional characteristics, use the basic formulas, and conduct simple experimental tests on transistor circuits, including amplifier, oscillator, and control circuits.

- A.1 Have students read, view films, and discuss how semiconductor devices are manufactured and the physical structure of the finished devices.
- B.1 Have students read, view films, solve simple circuit problems, and participate in class discussions on diode devices and circuit applications thereof.
- B.2 In the laboratory have students assemble various rectifiers (power supply) circuits with and without filters and other diode circuits. Make measurements toward comparing these circuits with one another and with the appropriate theoretical values which are calculated by the students.
- C.1 Have students read, view films, participate in class discussions, and calculate answers to simple problems involving various transistor devices and simple circuits which use transistors.
- C.2 In the laboratory have students assemble a variety of transistor circuits, which perform the functions given in the topical outline, and make measurements

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XV: Discrete Semiconductor Devices and Circuits**

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**SELECTED STUDENT COMPETENCIES**

**SAMPLE LEARNING ACTIVITIES**

**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

- A. Visualize and describe the physical structure of and manufacturing process by which various semiconductor devices are fabricated.
- B. Understand and describe the functional characteristics, use the basic formulas, and make experimental measurements on various semiconductor diode circuits.
- C. Understand and describe the functional characteristics, use the basic formulas, and conduct simple experimental tests on transistor circuits, including amplifier, oscillator, and control circuits.

- A.1 Have students read, view films, and discuss how semiconductor devices are manufactured and the physical structure of the finished devices.
- B.1 Have students read, view films, solve simple circuit problems, and participate in class discussions on diode devices and circuit applications thereof.
- B.2 In the laboratory have students assemble various rectifiers (power supply) circuits with and without filters and other diode circuits. Make measurements toward comparing these circuits with one another and with the appropriate theoretical values which are calculated by the students.
- C.1 Have students read, view films, participate in class discussions, and calculate answers to simple problems involving various transistor devices and simple circuits which use transistors.
- C.2 In the laboratory have students assemble a variety of transistor circuits, which perform the functions given in the topical outline, and make measurements

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT XV: Discrete Semiconductor Devices and Circuits**

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                           | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</p> <p>D. Understand and express verbally and/or in writing the functional purpose and characteristics, use the basic associated formulas, and conduct experimental tests on simple circuits which use the various special function semiconductor devices.</p> | <p>toward understanding the functional categories and of comparing different circuits within each category. Measured values may also be compared with the appropriate theoretical values which are calculated by the students.</p> <p>D.1 Have students read texts and periodical articles, view films, participate in class discussions, and use applicable formulas to solve simple problems regarding special function semiconductor devices and circuits which reflect applications of these devices.</p> <p>D.2 In the laboratory have students assemble circuits which use special function devices, as identified in the device characteristics and the topical outline, and make measurements, toward understanding the circuit operation. Measured values may be compared with appropriate theoretical values which are calculated by the students.</p> |

## UNIT XVI

### Integrated Devices and Circuits, Analog

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of the use categories of analog integrated circuits and their functional characteristics.
2. Experiences in conducting basic laboratory measurements toward understanding both the operational aspects and the uses of analog integrated circuits.

#### 1.0.0 IC Amplifiers

- 1.1.0 Non-inverting
- 1.2.0 Inverting
- 1.3.0 Differential
- 1.4.0 Summing
- 1.5.0 Spectiality amplifiers

#### 2.0.0 IC Timers and Oscillators

- 2.1.0 Possible waveforms: referenced and floating
- 2.2.0 Timing components and formula(s)
- 2.3.0 Astable, monostable, and bistable principles
- 2.4.0 Triggering and voltage control principles

#### 3.0.0 Regulators: Power Supplies

- 3.1.0 Fixed voltage
- 3.2.0 Variable voltage
- 3.3.0 Dual voltage and tracking

#### 4.0.0 Basic Communications IC Circuits

- 4.1.0 A-M receivers and transmitters
- 4.2.0 F-M receivers and transmitters

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT XVI: Integrated Devices and Circuits, Analog**

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                        | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <p>A. Understand and describe the basic characteristics, use the basic formulas, and make experimental measurements to determine parameters of various integrated circuit amplifiers.</p> <p>B. Understand and describe the basic operational characteristics, use the basic formulas, and conduct simple experimental tests on timer and oscillator circuits which use integrated circuits.</p> | <p>A.1 Have students read, participate in class discussions, and solve simple problems regarding IC amplifier circuits.</p> <p>A.2 In the laboratory have students assemble various IC amplifier circuits and make measurements toward determining the circuits' performance characteristics. Some of these measured values may be compared with theoretical values calculated earlier by the students.<br/>Note: The uA741 IC Operational Amplifier is good for amplifier experiments.</p> <p>B.1 Have students read, participate in class discussions, and solve simple problems regarding IC timer and oscillator circuits.</p> <p>B.2 In the laboratory have students assemble various IC timer and oscillator circuits and make experimental measurements toward determining the operational characteristics of these circuits. Some of these measured values may be compared with theoretical values calculated by the students. <u>Note:</u> The 555 Timer and 566 Function Generator are good IC's for experimentation.</p> |

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**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XVI: Integrated Devices and Circuits, Analog**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                  | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</b></p>                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p>C. Understand and describe the basic operational characteristics, use the basic formulas, and conduct simple experimental tests on voltage and/or current regulator circuits which employ applicable integrated circuits.</p>                                                                                                               | <p>C.1 Have students read, participate in class discussions, and solve simple problems regarding IC regulator circuits.</p>                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                | <p>C.2 In the laboratory have students assemble and make appropriate measurements on various IC regulator circuits toward determining the circuits' operational characteristics. Two important regulator performance tests are the percent voltage regulation and the percent ripple. Some of these measured values provide a basis for comparison with theoretical values calculated by students. <u>Note:</u> The uA723 Voltage Regulator is one IC which may be used for experimentation.</p> |
| <p>D. Understand and express verbally and/or in writing the basic principles of amplitude modulation and frequency modulation, use the basic formulas, and conduct simple experiments on receiver, and possible transmitter, circuits which employ integrated circuits. <u>Note:</u> Transmitter circuits must conform to FCC regulations.</p> | <p>D.1 Have students read and participate in class discussions regarding essential principles of AM and FM receivers and additionally the basic FCC regulations regarding transmitters.</p>                                                                                                                                                                                                                                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                | <p>D.2 Have students interview or listen to a guest speaker such as a radio or television station broadcast engineer.</p>                                                                                                                                                                                                                                                                                                                                                                        |

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XVI: Integrated Devices and Circuits, Analog**

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| SELECTED STUDENT COMPETENCIES                            | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                       |
|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| THE LEARNING ACTIVITIES SHOULD<br>ENABLE THE STUDENT TO: | D.3 In the laboratory have students<br>assemble IC receiver circuits<br>and make measurements toward<br>understanding the concepts<br>involved in and functional<br>characteristics of such circuits.<br>Transmitter circuits may also<br>be analyzed if they are operated<br>within applicable FCC regulations. |

## UNIT XVII

### Introduction to Digital Electronics

#### OBJECTIVES:

This unit is meant to provide the student with:

1. An understanding of the fundamental operations of the basic digital electronic building blocks.
2. Experiences in conducting laboratory measurements toward understanding the functional aspects and uses of basic digital components.

#### 1.0.0 Basic Binary Levels and Arithmetics

1.1.0 Positive versus negative logic

1.2.0 Characteristic digital voltage levels

1.3.0 Amplification: need and achievement

1.4.0 Number system principles

1.4.1 System base and digit positions

1.4.2 Decimal system (use as introductory example)

1.4.3 Binary system

1.4.4 Octal system

1.4.5 Hexadecimal system

1.4.6 Conversions between systems

1.5.0 Truth table definition (Use examples for each 2.1.0 through 2.4.0 below)

#### 2.0.0 Basic Digital Gates

2.1.0 Inverters

2.2.0 AND and NAND gates

2.3.0 OR and NOR gates

2.4.0 Using NAND and NOR gates as universal gates

#### 3.0.0 Basic Level Indicators

3.1.0 The LED

3.2.0 The numeric (seven-segment) display

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XVII: Introduction to Digital Electronics**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                    | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <p>A. Understand and express verbally and in writing the concepts which are fundamental to digital electronics including characteristics voltage levels, the basics of digital-circuit-used number systems, and the use of truth tables.</p> | <p>A.1 Have students read and participate in class discussions about the concepts which are fundamental to understanding and future use of digital circuits.</p> <p>A.2 Have students practice converting decimal numbers into their binary, and possibly octal and hexadecimal, number equivalents, and vise versa.</p> <p>A.3 In the laboratory have students conduct tests on various sections of a hex-inverter toward determining the input voltage level(s) which cause the output to change state and the LO and HI output voltage level(s) which result. These levels may then be compared with manufacturers' specifications and/or industry standard voltage levels.</p> <p>A.4 Have students view films and use other audio-visual aids which may help them in understanding the fundamental logic and digital electronic concepts of this unit.</p> |

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XVII: Introduction to Digital Electronics**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                             | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</p>                                                                                                              |                                                                                                                                                                                                                                                                                                                            |
| <p>B. Understand and express verbally and in writing the logic functions of the basic logic gates used in digital electronics and the use of associated truth tables.</p> | <p>B.1 Have students read and participate in class discussions regarding the basic digital electronic logic gates, their logic functions, and the associated truth tables.</p>                                                                                                                                             |
|                                                                                                                                                                           | <p>B.2 In the laboratory have students wire and power each of the basic logic gates, apply the various combinations of appropriate input voltage levels, and measure the resultant output voltage levels. These output versus input levels should then be compared with the truth table analysis values for each gate.</p> |
|                                                                                                                                                                           | <p>B.3 (See A.4 above)</p>                                                                                                                                                                                                                                                                                                 |
| <p>C. Understand and describe the operational characteristics and proper use of various available logic level indicator devices.</p>                                      | <p>C.1 Have students read and participate in class discussions regarding the characteristics and use of various logic level indicator devices.</p>                                                                                                                                                                         |
|                                                                                                                                                                           | <p>C.2 In the laboratory have students use a variety of indicator devices so as to acquaint the students with the use of each.</p>                                                                                                                                                                                         |
|                                                                                                                                                                           | <p>C.3 (See A.4 above)</p>                                                                                                                                                                                                                                                                                                 |

## UNIT XVIII

### Basic Arithmetic Devices

#### OBJECTIVES:

This unit is meant to provide the student with:

1. A basic knowledge of the performance characteristics of arithmetic devices used in digital electronics.
2. Experiences in laboratory measurements on arithmetic devices toward reinforcement of the operation and uses of such devices.

#### 1.0.0 Basic Binary Operations

- 1.1.0 Addition and carry principles
- 1.2.0 Subtraction and borrow principles
- 1.3.0 Multiplication: repeated addition and shift principles
- 1.4.0 Division: repeated subtraction and comparison principles

#### 2.0.0 Adders and Subtractors

- 2.1.0 Half- and full-adders; sum and carry outputs
- 2.2.0 Half- and full-subtractors; difference and borrow outputs
- 2.3.0 Serial and parallel bit adders and subtractors
- 2.4.0 Programmable adders and subtractors

#### 3.0.0 Digital Signal Sources

- 3.1.0 Astable multivibrators
- 3.2.0 Monostable multivibrators
- 3.3.0 Timers
- 3.4.0 The schmitt trigger

#### 4.0.0 Flip-Flops

- 4.1.0 R-S flip-flop
- 4.2.0 D-type flip-flop

## UNIT XVIII

4.3.0 J-K flip-flop

5.0.0 Binary Counters

5.1.0 Counter terminology and limitations

5.2.0 Binary ripple counters

5.3.0 Parallel counters

5.4.0 Combinational (various moduli) counters

5.5.0 BCD counters and applications

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT XVIII: Basic Arithmetic Devices**

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                      | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p>                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>A. Use and understand the basic arithmetic operations as applied to the binary number system.</p>                                                                                               | <p>A.1 Have students read, participate in class discussions, and solve simple problems involving basic arithmetic operations using binary numbers.</p>                                                                                                                                                                                                                                            |
| <p>B. Use simple arithmetic digital electronic devices, such as adders and subtractors, toward reinforcing of understanding the binary number system and the applicable arithmetic operations.</p> | <p>B.1 Have students read about, participate in class discussions on, and solve simple problems of their own choosing or from texts involving arithmetic operations.</p>                                                                                                                                                                                                                          |
| <p>C. Understand and use basic digital electronics signal sources, emphasizing criteria which make them compatible with digital logic circuits.</p>                                                | <p>B.2 In the laboratory have students wire digital electronic arithmetic devices, apply selected combinations of inputs, and note (or read) the resultant output levels which represent the mathematical answer of the inputs. These answers should be compared with the answers obtained via mental solution.</p>                                                                               |
|                                                                                                                                                                                                    | <p>C.1 In the laboratory have students use and analyze the performance of several digital signal sources devices with emphasis on the device's or circuit's ability to produce a compatible signal or, in the case of the schmitt trigger, to interface a sine-wave source with digital circuits. <u>Note:</u> Some coverage of this section's content appeared in section 2.0.0 in unit XVI.</p> |

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XVIII: Basic Arithmetic Devices**

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**SELECTED STUDENT COMPETENCIES**

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**THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:**

- D. Understand the basic characteristics, the unique features, and proper use of a variety of flip-flops which are applicable to digital electronics.
  
- E. Understand and describe the basic functional characteristics of a variety of binary counters and to use them in laboratory experiments.

**SAMPLE LEARNING ACTIVITIES**

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- D.1 Have students read about and participate in class discussions on the types of flip-flops, their operation, and their uses.
  
- D.2 In the laboratory have students experiment with data inputs, clock pulsing, and noting the responses of various types of flip-flops.
  
- E.1 In the laboratory have students experiment with various types of binary counters toward reinforcing understanding of how each responds to input data and their potential applications in digital electronic devices or equipment.
  
- E.2 Have students read about and participate in class discussions on the functioning and applications of various types of binary counters.

## UNIT XIX

### Basic Support Devices

#### OBJECTIVES:

This unit is meant to provide the student with:

1. A basic knowledge of the performance characteristics of digital electronic support devices.
2. Experiences in laboratory measurements on support devices toward reinforcement of the operation and uses of such devices .

#### 1.0.0 Shift Registers/Counters

1.1.0 Serial-shift

1.2.0 Parallel-shift

1.3.0 Shift right/left

1.4.0 Presettable

1.5.0 Up/down counters

#### 2.0.0 Basic Memory Units

2.1.0 RAM

2.2.0 ROM

2.3.0 PROM

2.4.0 EPROM

#### 3.0.0 Numeric Display Techniques

3.1.0 Decoders and drivers

3.2.0 The seven-segment readout indicator

3.3.0 The bistable latch

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

**UNIT XIX: Basic Support Devices**

| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                          | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</b></p> <p>A. Understand and describe the basic data-handling principles of shift registers and counters and use such devices in laboratory experimentation and in practical applications.</p> <p>B. Use basic digital electronic memory devices in experiments and in practical applications. Understand and describe the means by which data is stored in and/or retrieved from such memory devices.</p> | <p>A.1 Have students read, participate in class discussions, and solve diagram problems regarding the data-handling functioning of shift registers and counters.</p> <p>A.2 In the laboratory have students connect and operate various shift registers and counters toward reinforcing understanding of their data-handling operations.</p> <p>A.3 Have students view films and use other audio-visual materials which will aid their understanding of digital electronic support devices and the applications of such devices.</p> <p>B.1 Have students read and participate in class discussions regarding the basic memory devices used in digital electronics.</p> <p>B.2 In the laboratory have students connect and then conduct simple experiments involving the storage/retrieval of binary data into/out of basic digital electronic memory devices.</p> <p>B.3 (See A.3 above)</p> |

SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR

Electrical/Electronic Technology

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UNIT XIX: Basic Support Devices

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                                                                                          |
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| <p>THE LEARNING ACTIVITIES SHOULD ENABLE THE STUDENT TO:</p> <p>C. Understand and describe how binary data is decoded for decimal numeric display and the principles by which display systems operate and use display systems in experiments and practical applications.</p> | <p>C.1 Have students read, participate in class discussions, and solve code problems toward understanding how characters of the binary, octal, decimal, and hexadecimal numbers can be formed on a seven-segment display.</p> <p>C.2 In the laboratory have students connect the various devices of a simple display system and then check out various combinations of binary digits toward achieving display of various characters.</p> <p>C.3 (See A.3 above)</p> |

## UNIT XX

### Microprocessor Basics and Applications

#### Note to Instructor:

Actual student use of a microprocessor in this course may be difficult or impossible in many schools today, but must definitely be considered in the future. This difficulty, however, does not lessen the necessity for students to be aware of basic information regarding the microprocessor. Students who show an interest in this area after completing this course might be encouraged toward additional study of microprocessors in an Individual Technical Problems course.

#### Objectives:

This unit is meant to provide the student with:

1. Information regarding the historical development, the essential parts and make-up, and the usual peripheral devices associated with microprocessors in general.
2. An understanding of how the microprocessor has and will continue to effect various aspects of our society and the entire world.
3. An opportunity, if possible, to explore the functioning and use of a microprocessor unit toward a variety of applications.

#### 1.0.0 Historical Perspectives of Computers and Microprocessors

##### 1.1.0 The abacus

##### 1.2.0 Mechanical calculators

##### 1.3.0 Vacuum-tube versions

##### 1.4.0 Discrete semiconductor versions

##### 1.5.0 Early integrated-circuit versions

##### 1.6.0 Medium-scale integrated circuit (MSI) versions

##### 1.7.0 Large-scale integrated circuit (LSI) versions

Note: The above may be compared/contrasted with regard to date of origin, functions performed, physical size, speed of operation, power consumption, cost, predominant uses, versatility, socioeconomic impact, and other factors.

## UNIT XX

### 2.0.0 Microcomputer Parts/Peripherals and Functions

- 2.1.0 The central processing unit or CPU
- 2.2.0 Memory units; ROM, RAM, etc.
- 2.3.0 Input/output or I/O: interfacing units
- 2.4.0 External sensors for input
- 2.5.0 External actuators for output

### 3.0.0 Microcomputer/Microprocessor Applications

- 3.1.0 Data processing
- 3.2.0 Scientific computing
- 3.3.0 Monitoring and control
  - 3.3.1 Machines
  - 3.3.2 Environmental
  - 3.3.3 Processes
  - 3.3.4 Biomedical devices
  - 3.3.5 Personal convenience devices

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XX: Microprocessor Basics and Applications**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                    | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</b></p>                                                                                                                          |                                                                                                                                                                                                                                                                                                                    |
| <p>A. Comprehend and describe verbally or in writing the historical development of computing devices, machines, and processors and the impacts they have had on various segments of society.</p> | <p>A.1 Have students read, participate in class discussions, view films, and/or listen to guest speakers regarding the development of computing devices, machines, microprocessors, etc.</p>                                                                                                                       |
| <p>B. Understand and describe the basic parts or modules which make up a modern microcomputer system and the functions and interrelationships of these various parts.</p>                        | <p>A.2 Have individual or groups of students choose one type of "computer", conduct research on its features, uses, and societal impact and write or give a class report on the findings.</p>                                                                                                                      |
|                                                                                                                                                                                                  | <p>B.1 Have students read, participate in class discussions, view films, and/or listen to guest speakers regarding the makeup and functioning of modern microcomputer systems.</p>                                                                                                                                 |
|                                                                                                                                                                                                  | <p>B.2 Take students on a field trip or tour of a business establishment or industry where they can see and ask questions about the use of a particular microcomputer system. Suggestions may include a bank, utility company, telephone company, store where inventories are handled by a microcomputer, etc.</p> |

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XX: Microprocessor Basics and Applications**

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| SELECTED STUDENT COMPETENCIES                                                                                                                                                                                                                                                        | SAMPLE LEARNING ACTIVITIES                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>THE LEARNING ACTIVITIES SHOULD<br/>ENABLE THE STUDENT TO:</b></p> <p>C. Comprehend and describe a variety of applications of microcomputers and microprocessors, how they are adapted to respond to various sensed input data, and how they may control various processes.</p> | <p>C.1 Have students read, participate in class discussions, view films, etc., regarding the board applications of microcomputers and microprocessors.</p> <p>C.2 Have individual or groups of students choose a real or potential microcomputer/microprocessor application, conduct research by a variety of means on that application, and write or give a class report on the findings.</p> |

## UNIT XXI

### Electronic Assembly Methods

#### Note to Instructor:

This unit is optional within this course because it involves some content and activities normally associated with manufacturing (see Course Code 10026). Thus, joint coverage of this unit's content may be a viable approach.

It should be realized that because most electronic circuits contain at least discrete semiconductors, students should have a basic familiarity with such devices before attempting the assembly of an electronic device. Therefore, this unit may begin anytime after the beginning of Unit XV of this course.

In this unit the proper planning of electronic device assembly is considered of greater educational benefit than the actual assembly itself. Therefore, the instructor should not consider students' assembly of kits which already contain assembly directions as appropriate substitutes for this unit's content.

#### Objectives:

This unit is meant to provide the student with:

1. A basic knowledge of procedures by which correct components/parts of an electronic device may be obtained and a cost estimate of the device may be made.
2. Experience in transforming a device's schematic-given information into a multiview sketch or drawing from which actual device assembly can proceed.
3. An understanding of the methods by which electronic devices may be assembled and experience in using one of these methods.

#### 1.0.0 Device Components/Parts Selection and Sources

1.1.0 Passive components: electrical and physical sizes

1.2.0 Active components

1.2.1 Discrete: manufacturer's identification, physical size, and lead arrangement

1.2.2 Integrated: manufacturer's identification, physical size, and lead arrangement

1.3.0 Component substitutions

1.4.0 Component sources

## UNIT XXI

- 1.4.1 Used/surplus component sources
  - 1.4.2 Electronic catalog houses
  - 1.4.3 Local distributors
- 1.5.0 Mechanical parts selection - enclosure and other
- 1.6.0 Device cost analysis
- 2.0.0 Assembly Methods: Limitations, Materials, Procedures, and Layout Sketching
  - 2.1.0 Point-to-point wiring assembly
  - 2.2.0 Terminal-board assembly
    - 2.2.1 Board mounted parts
    - 2.2.2 Enclosure mounted parts
    - 2.2.3 Interconnecting and off-board wiring
  - 2.3.0 Etched circuit-board assembly
    - 2.3.1 Board mounted parts
    - 2.3.2 Circuit-board layout, etching, drilling
    - 2.3.3 Enclosure mounted parts
    - 2.3.4 Off-board wiring
- 3.0.0 Device Performance Testing
  - 3.1.0 Node voltage measurement
  - 3.2.0 Signal tracing
  - 3.3.0 Trouble-shooting techniques

# SELECTED STUDENT COMPETENCIES AND SAMPLE LEARNING ACTIVITIES FOR

## Electrical/Electronic Technology

### UNIT XXI: Electronic Assembly Methods

#### SELECTED STUDENT COMPETENCIES

#### SAMPLE LEARNING ACTIVITIES

THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:

A. Select the proper electrical/  
electronic components and  
other parts for use in the  
assembly of an electronic  
device, and make an estimate  
of time and cost for its  
assembly.

A.1 Have students read texts and  
other literature which  
describes and illustrates  
electronic assembly methods.

A.2 Provide all students with  
the same instructor chosen  
electronic device schematic  
and electronic components  
catalogs or literature and  
lead them, as a class, through  
the process of locating and  
selecting the proper components  
and parts. During this process,  
point out various choice options  
including cost and possible  
substitutions.

B. Proceed with components/parts  
selection and procurment,  
general and detail sketching  
of assembly and final  
appearance, component and  
part preparations, board  
mounting of components,  
enclosure mounting of parts  
and components, and final  
wiring of an electronic  
device assembled via either  
the terminal-board or the  
etched circuit board wiring  
method.

B.1 Provide students (in groups)  
with used electronic devices  
of either non-useable or  
useable condition and of  
recent manufacture and with  
schematics of those devices.  
Have the students inspect the  
devices, sketch sections  
thereof, and identify the  
sketched components by the  
schematic given identifications,  
all toward better understanding  
of electronic assembly methods.

B.2 Allow each student to choose,  
with instructor approval and  
within reasonable limits, an  
electronic device of personal

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XXI: Electronic Assembly Methods**

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**SELECTED STUDENT COMPETENCIES**

THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:

- C. Plan and proceed with the performance testing of an electronic device, assembled as outlined under B above, including node voltage measurement, signal tracing, troubleshooting, and/or other means, and the preparation of a report on the entire electronic device assembly and testing activity.

**SAMPLE LEARNING ACTIVITIES**

interest and potential use. Have the student proceed with the planning and assembly of that device in accord with the steps given in competency B.

Note: The instructor should advise students of and carry through on the axiom that, "The learning and satisfaction gained from planning, assembling, and testing a simple device in a proper manner generally exceeds that gained from trying but failing to do the same with too complex a device."

- C.1 Each student should first spend time with the instructor preparing an itemized list of steps to be followed in the initial powering and functional testing of the device. After the device is proven to function properly, often after adjustments, signal tracing, some troubleshooting, etc., the student should proceed with measuring and recording node voltages, standard signals, and other information for future reference.

**SELECTED STUDENT COMPETENCIES  
AND SAMPLE LEARNING ACTIVITIES  
FOR**

**Electrical/Electronic Technology**

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**UNIT XXI: Electronic Assembly Methods**

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**SELECTED STUDENT COMPETENCIES**

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THE LEARNING ACTIVITIES SHOULD  
ENABLE THE STUDENT TO:

**SAMPLE LEARNING ACTIVITIES**

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C.2 After completion of C.1 above, have student prepare a complete written report on the device including schematic, specifications/identification and cost of components and parts actually used, assembly sketches, testing procedures and measured data, and a general commentary on difficulties encountered and what was learned.

## REFERENCES

### Texts and References:

Buban, Peter and Marshall Schmitt. Technical Electricity and Electronics. (2nd Edition). New York, New York: McGraw-Hill Book Company, 1977.

Gerrish, Howard W. and William E. Dugger. Electricity and Electronics. South Holland, Illinois: The Goodheart-Willcox Company, Incorporated. 1980.

Gilmore, Charles M. Beginners Guide to Microprocessors. Blue Ridge Summit, Pennsylvania: Tab Books. 1977

Goldberg, Joel. How to Make Printed Circuit Boards. New York: New York: McGraw-Hill Book Company. 1980.

Jung, Walter G. IC Timer CookBook. Indianapolis, Indiana: Howard W. Sams and Company, Incorporated. 1978.

Lancaster, Donald E. TTL Cookbook. Indianapolis, Indiana: Howard W. Sams and Company, Incorporated. 1974.

Matt, Stephen R. Electricity and Basic Electronics. South Holland, Illinois: The Goodheart-Willcox Company, Incorporated. 1980.

Ramirez and Weiss. Microprocessing Fundamentals - Hardware and Software. New York, New York: McGraw-Hill Book Company, Gregg Division. 1980.

Villanucci, Robert S., Alexander W. Avtgis, and William F. Megow. Electronic Techniques: Shop Practices and Construction. Englewood Cliffs, New Jersey: Prentice-Hall, Incorporated, 1974.

### Experiment Manuals:

Energy Concepts, Incorporated. Electricity Concepts: Unit I. Chicago, Illinois: Energy Concepts, Incorporated. 1976.

Energy Concepts, Incorporated. Electricity Concepts: Unit II. Chicago, Illinois: Energy Concepts, Incorporated. 1976.

Energy Concepts, Incorporated. Solid State Fundamentals. Chicago, Illinois: Energy Concepts, Incorporated. 1979.

Leach, Donald P. Experiments in Digital Principles. New York, New York: McGraw-Hill Book Company. 1976.

Miller, Rex and Nelson W. Fuller. Experiments for Electricity and Electronics. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing. 1978.

Zbar, Paul B. and Joseph G. Sloop. Electricity-Electronics Fundamentals: A Text-Lab Manual. (2nd Edition). New York, New York: McGraw-Hill Book Company. 1977.

Useful Periodicals:

Popular Electronics. One Park Avenue, New York, New York, 10016: Ziff-Davis Publishing Company.

Radio Electronics. 200 Park Avenue South, New York, New York, 10003: Gernsback Publications, Incorporated.

Sources for Films and Guest Speakers:

Montana Dakotas Utility Company

Northern States Power Company

Northwestern Bell Telephone Company

Ottertail Power Company

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